A Miniaturized Archimedean Spiral Antenna with Polarization Diversity

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Overview

- Motivation for this work
- Background to the subject
- The design
- Results
- Conclusions & Comments

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Motivation

- How do you make large antennas smaller?
- How can you maintain their efficiency?
- How can you preserve polarization?
- Can we create a scalable design?

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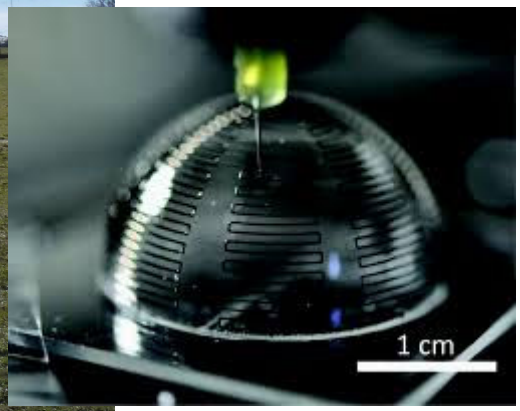
From A to B



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Why make antennas smaller?

- Easier to fit into devices
  - *Smart phones*
  - *Cars*
- Reduced visual impact
  - *Tempest*
  - *Planning permission*
  - *Aesthetics*
- Easier to handle

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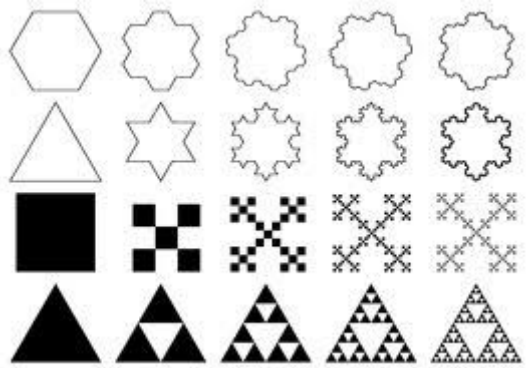
Background

- How do you make large antennas smaller?
  - *Dielectric loading*
  - *Fractals*
  - *Meander lines*
  - *Spirals*
  - *Meta materials - EBG/AMC/HIS*



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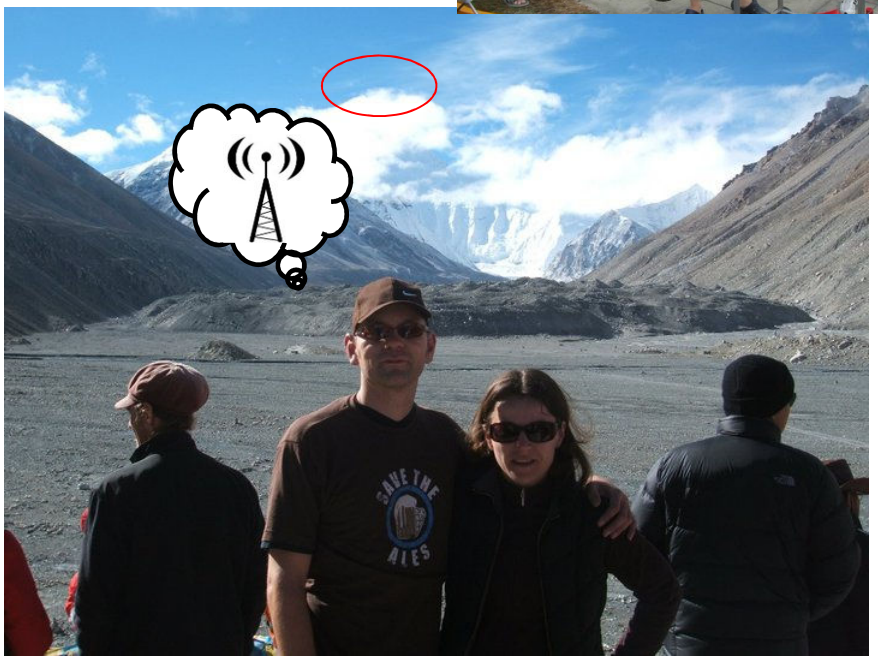
The forming of an idea…



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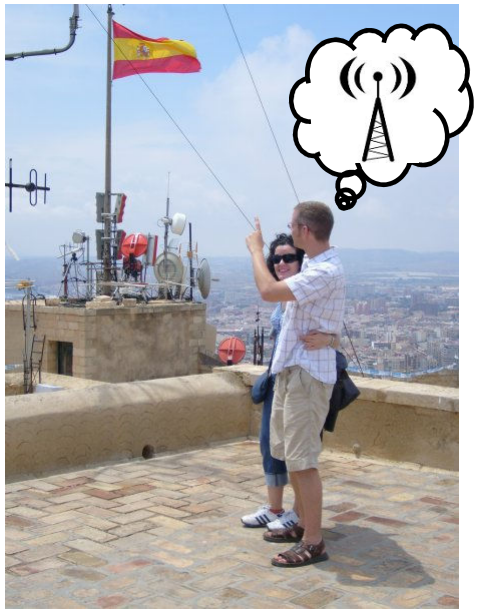
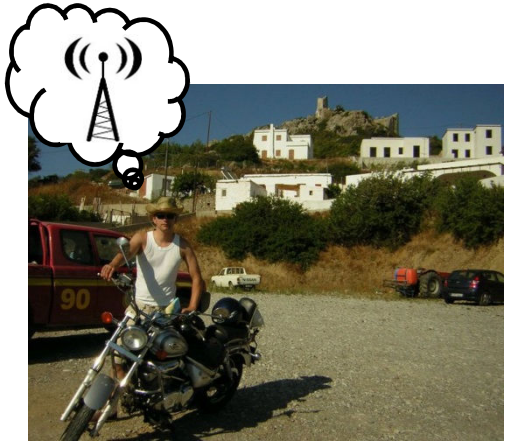
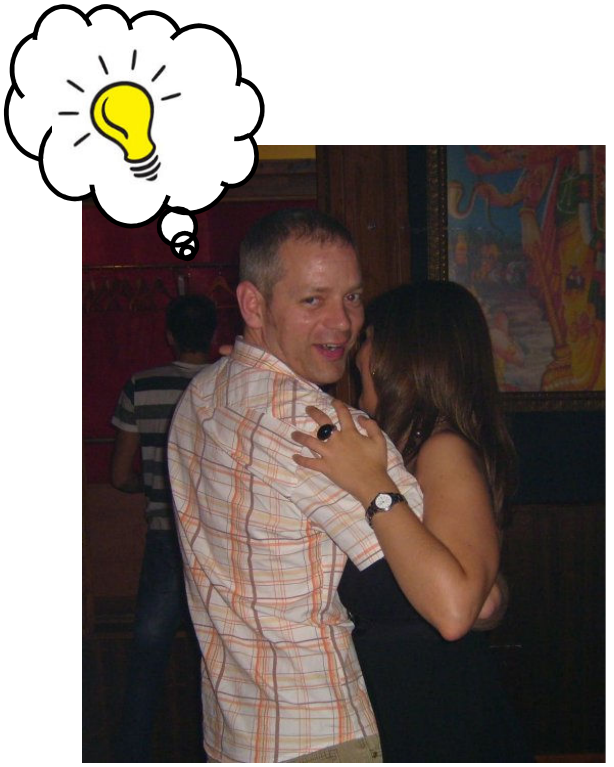
… Eureka!







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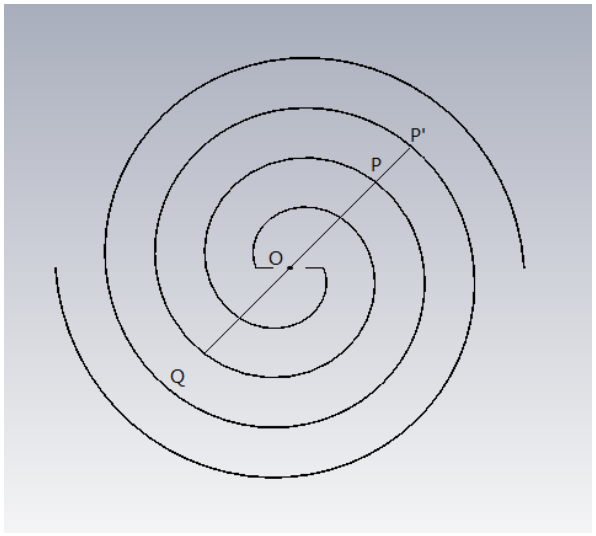

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Justification: Why a spiral?

- Easily scalable
- Easy to print
- Easy to manufacture
  - For tempest applications you can use a pipe bender.
  - For HF you can use radial supporting cables.

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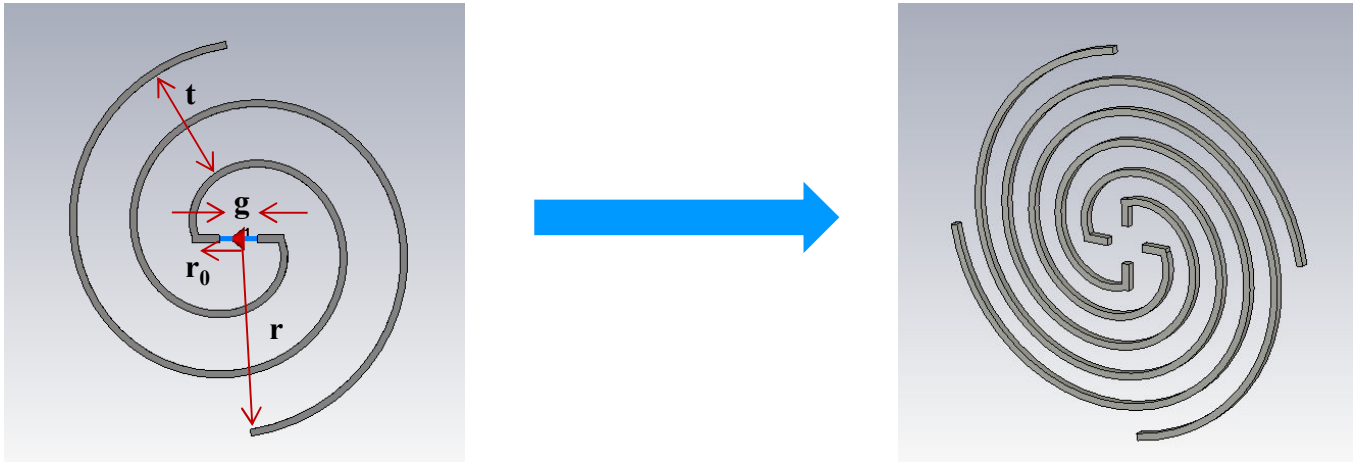
The design of a 4-arm Archimedean Spiral Antenna



$$r = r_0 + a\varphi$$

$$a = t/2\pi$$

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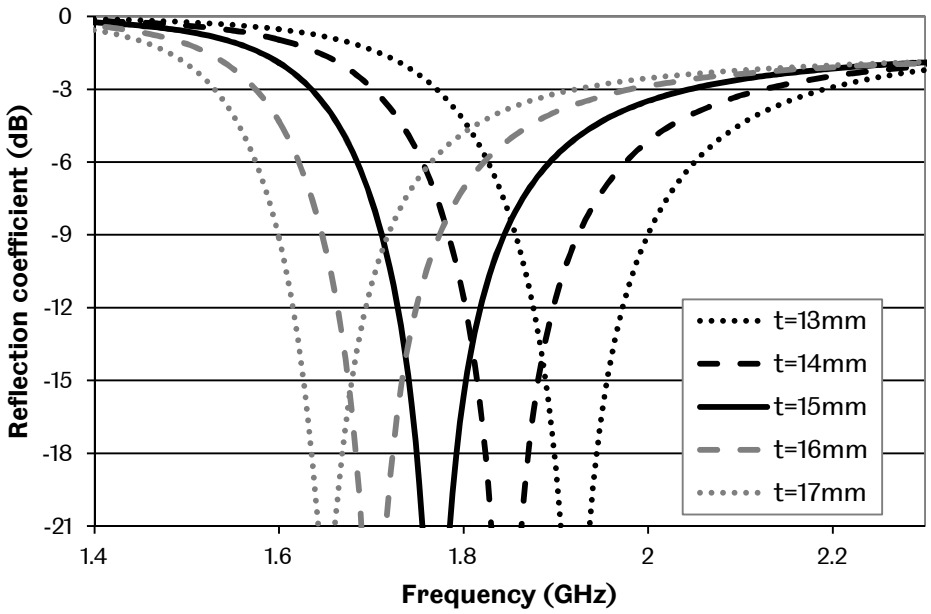
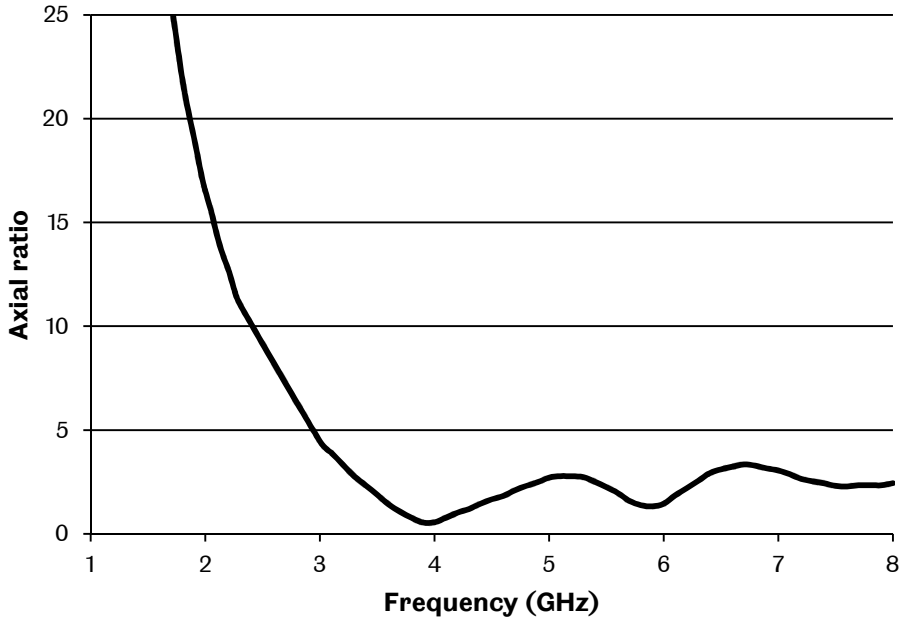
Reflection coefficient



Axial Ratio



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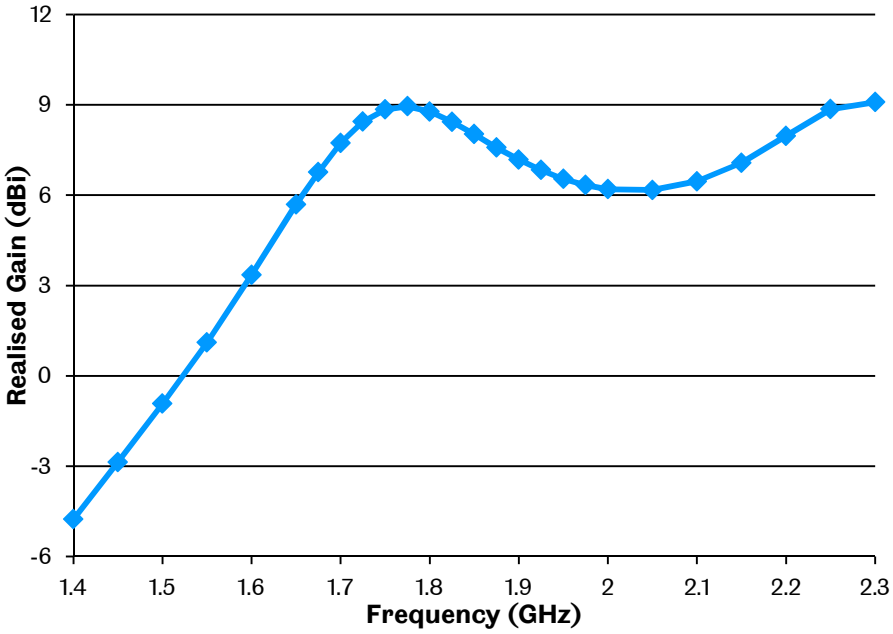
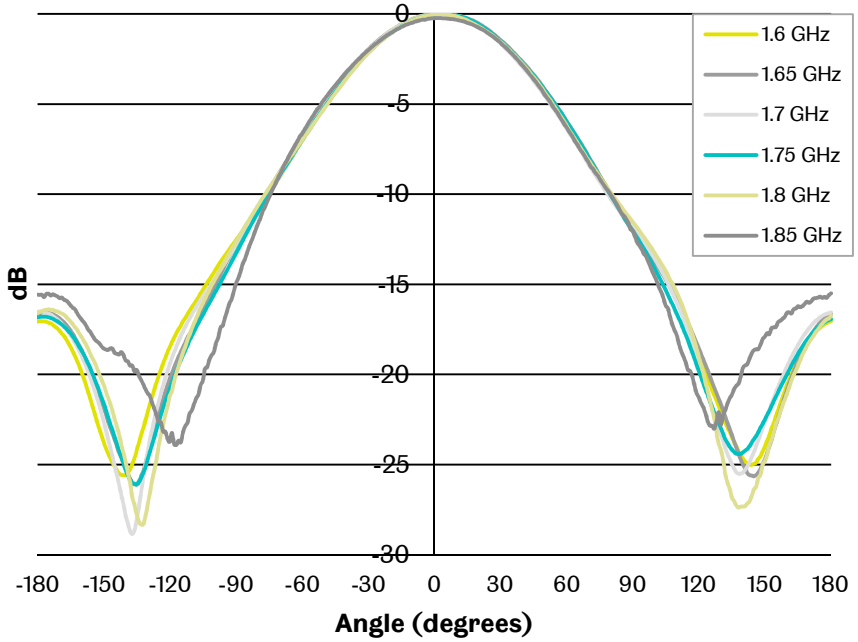
Gain



Radiation pattern



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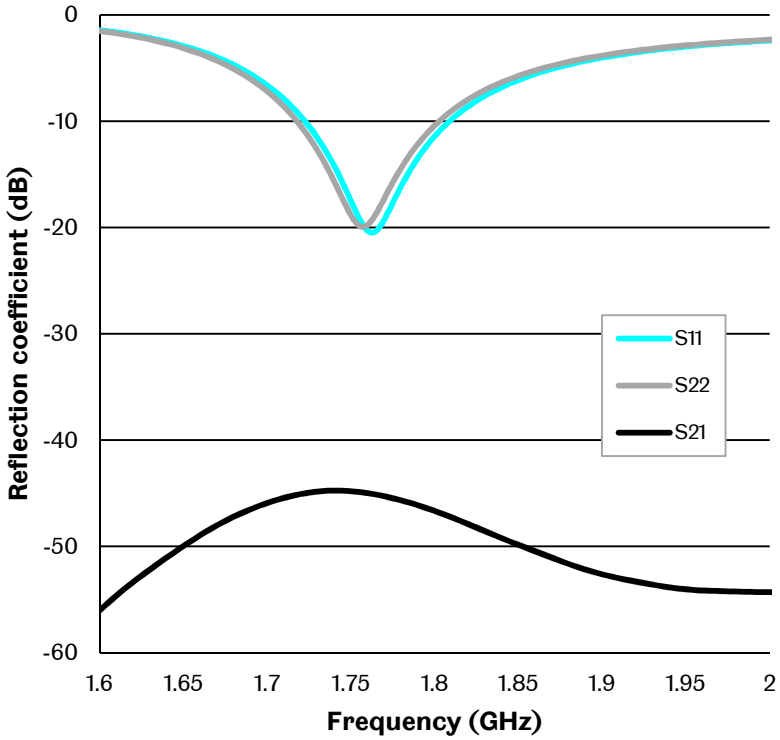
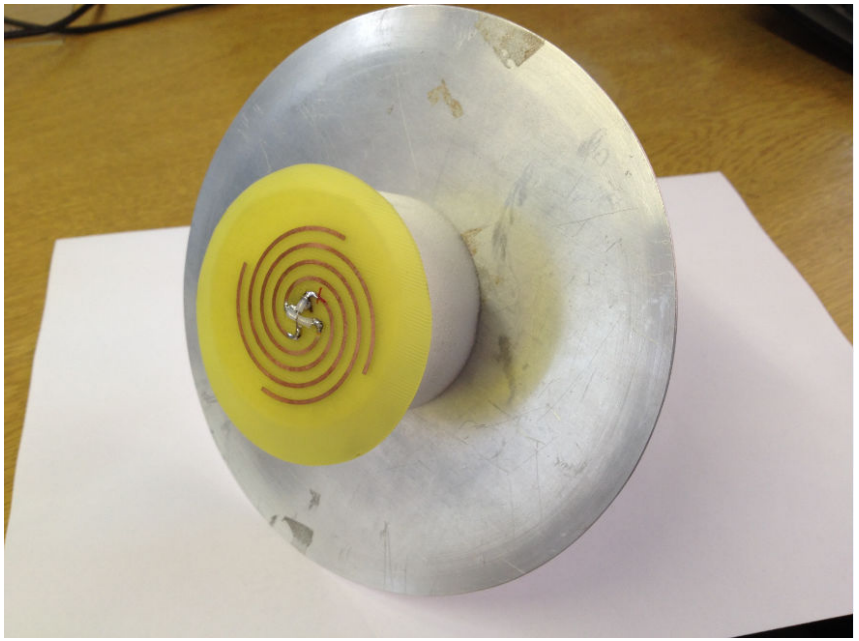
Results





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Summary of a Quad-arm Archimedean Spiral Antenna

- Frequency: 1.75GHz
- Reflection coefficient: -20dB
- Isolation: -45dB
- Gain: 9dBi
- Axial ratio: 38dB
- Diameter: 44.5mm
- Aperture reduction: 49%
- Thickness: $\lambda/4$
- Dielectric loading: NONE
- Meta-material: NONE

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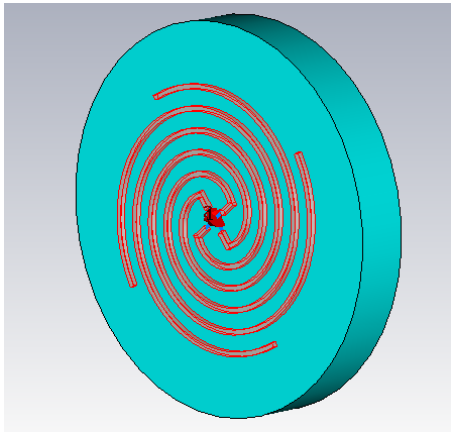
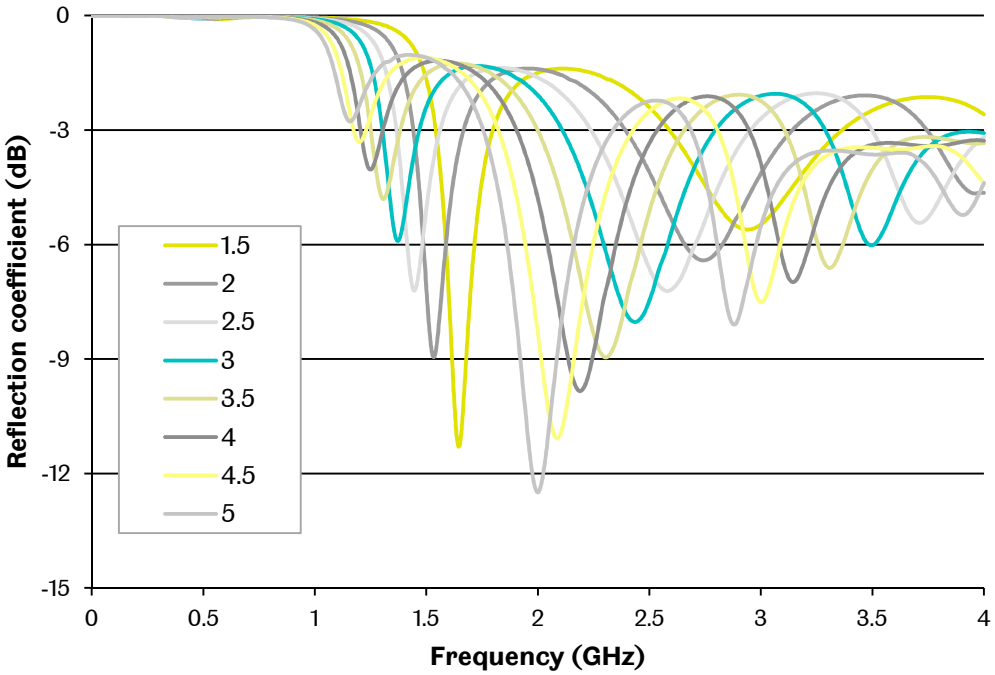
Dielectric loading



Variation of S11 with different ε



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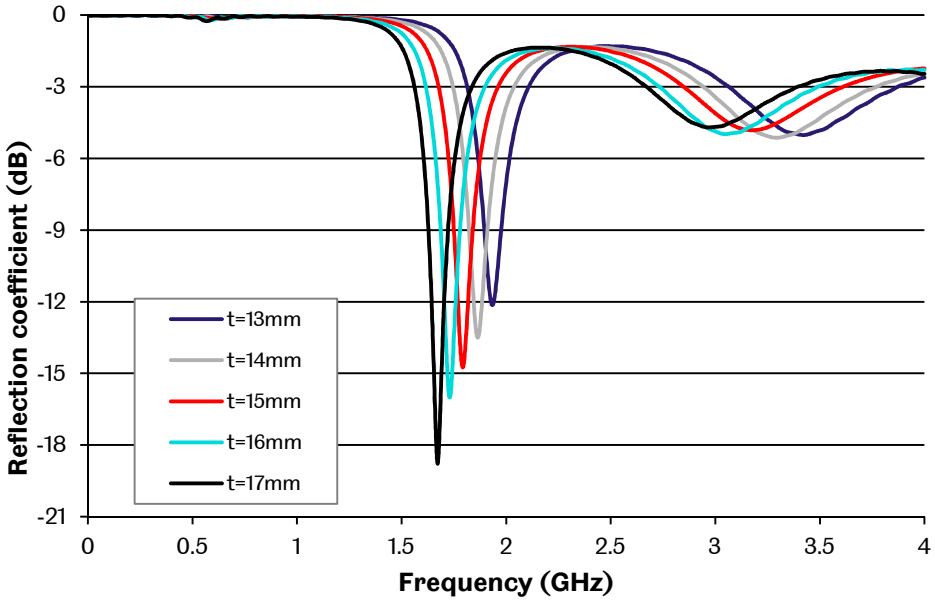
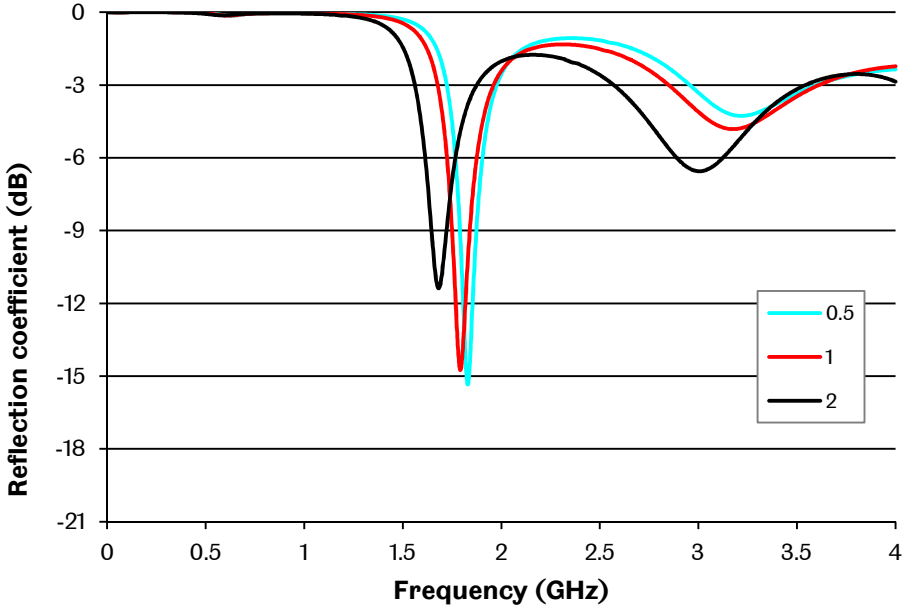
Reflection coefficient of different turns spacing



Reflection coefficient of different width of arm



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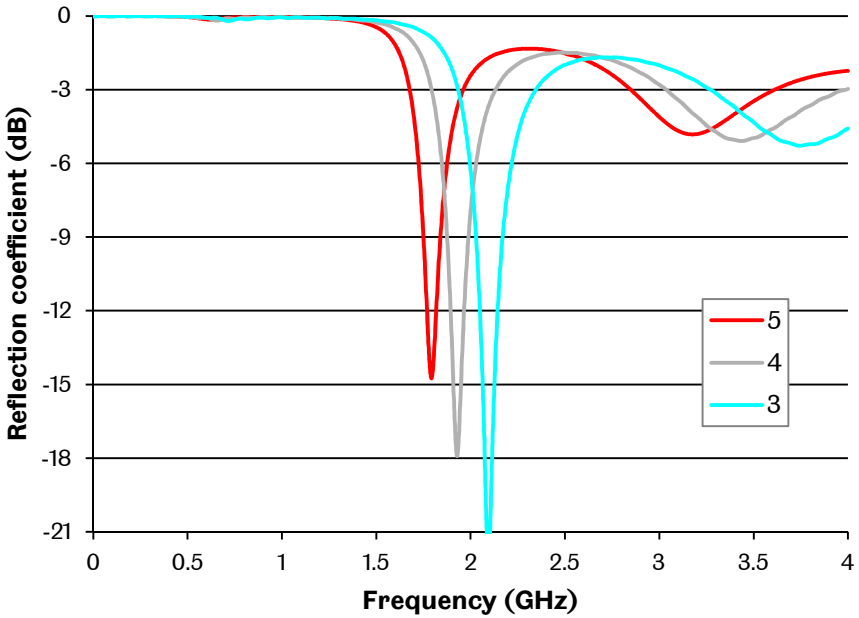
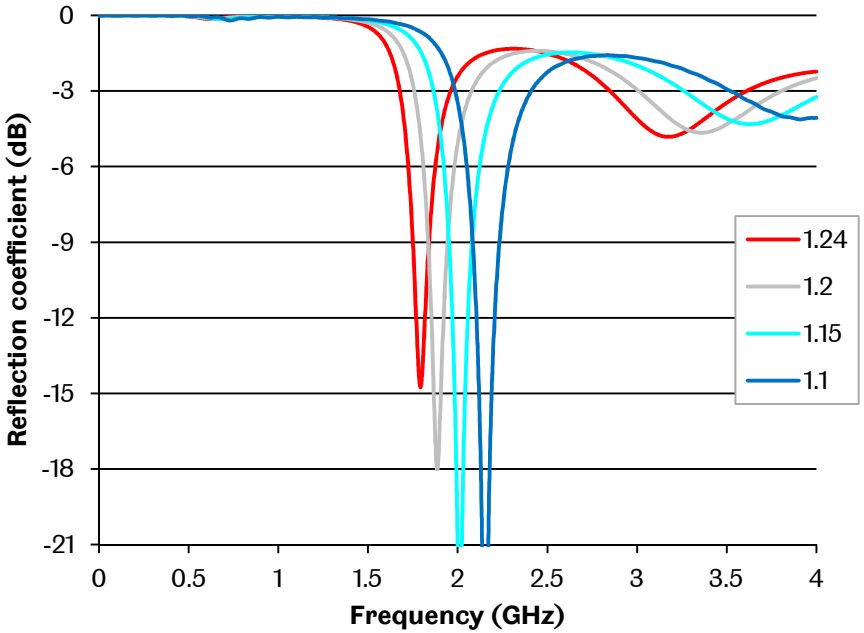
Reflection coefficient of different r0



Reflection coefficient of different number of turns



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Summary of a Quad-arm Dielectrically loaded Archimedean Spiral Antenna

- Frequency: 2.75GHz
- Reflection coefficient: -14dB
- Diameter: 44.5mm
- Aperture reduction: 45%
- Thickness: $\lambda/9$
- Dielectric loading: YES
- Meta-material: NONE

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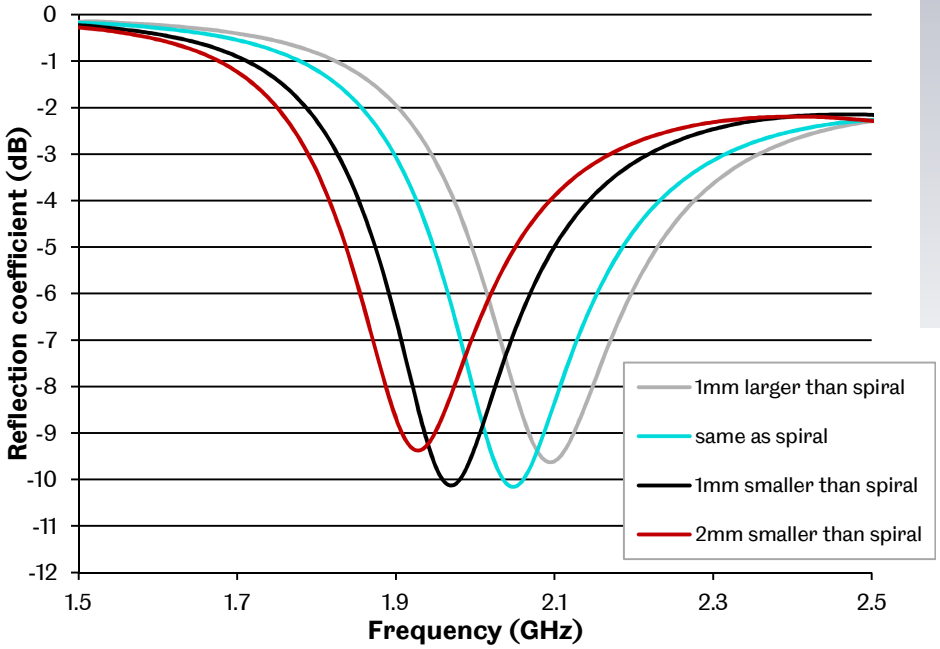
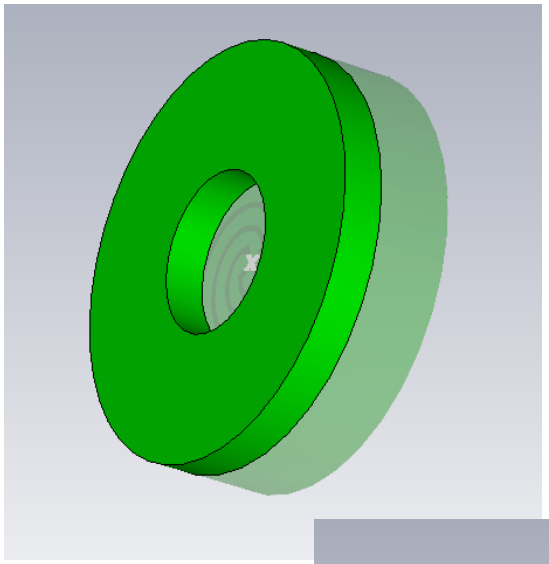
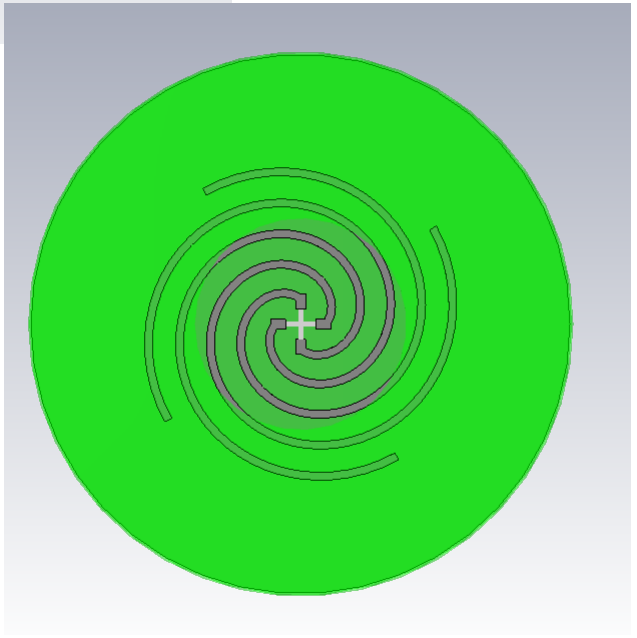
‘Polo’ Loaded







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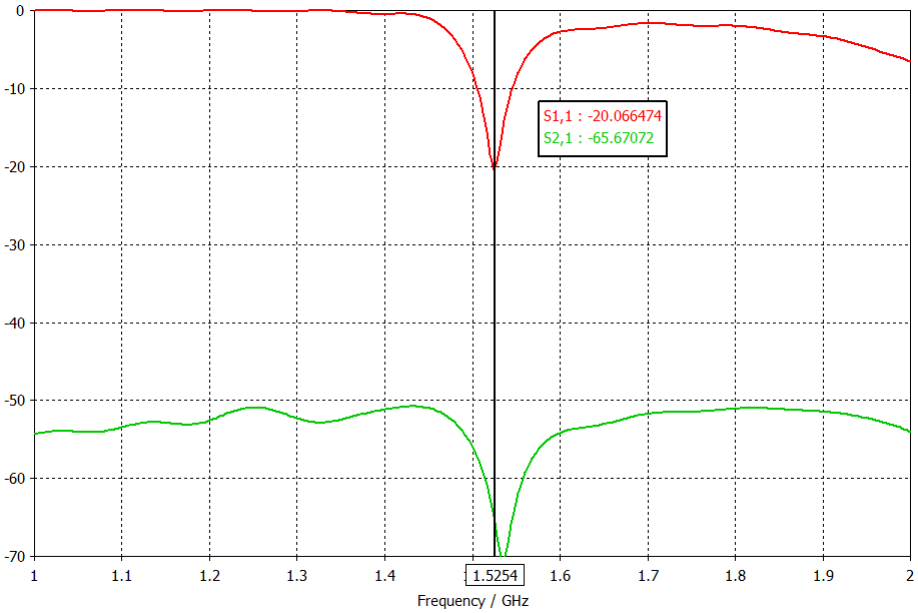
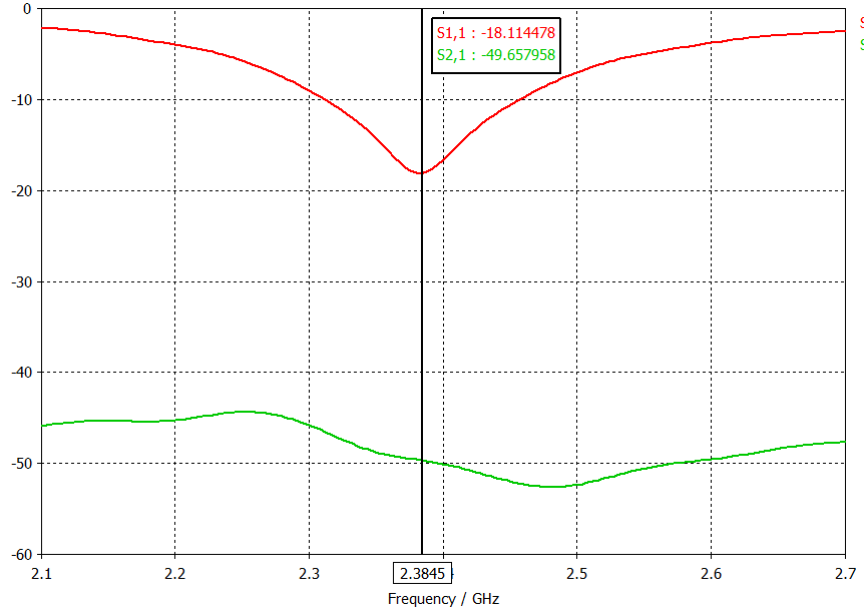
‘Polo’ Loaded





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Summary of a Quad-arm 'Polo' loaded Archimedean Spiral Antenna

- Frequency: 2.38GHz
- Reflection coefficient: -18.1dB
- Isolation: -50dB
- Gain: 5.9dBi
- Spiral Diameter: 32.5mm
- Aperture reduction: 49%
- Thickness: $\lambda/8$
- Dielectric loading: YES
- Meta-material: NONE

- Frequency: 1.52GHz
- Reflection coefficient: -20dB
- Isolation: -65dB
- Gain: 3.7dBi
- Spiral Diameter: 32.5mm
- Aperture reduction: 72.5%
- Thickness: $\lambda/10$
- Dielectric loading: YES
- Meta-material: NONE

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Conclusions

With a bit of clever thinking you can:

- Design a dual polarized, miniature Archimedean spiral antenna,
- Which is highly scalable, and
- Can be made even smaller using dielectric loading.

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Comments/Challenges

- Still have to try and make the design even smaller using EBG/AMC/HIS.
- Design an EBG/AMC/HIS which works at 6 MHz without dielectric material.
- Be very careful with your simulations!

(suggestions and/or collaborators welcome)

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Thank you!

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